



MINISTRY OF FUEL AND POWER

EXPLOSION AT
INGHAM COLLIERY, THORNHILL,
YORKSHIRE

REPORT

On the Causes of, and Circumstances attending the
Explosion which occurred at Ingham Colliery,
Thornhill, Yorkshire, on the 9th September, 1947

By A. M. BRYAN, J.P., B.Sc., F.R.S.E.
H.M. Chief Inspector of Mines

*Presented by the Minister of Fuel and Power to Parliament
by Command of His Majesty
June 1948*

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REPORT

On the Causes of, and Circumstances attending the Explosion which occurred at Ingham Colliery, Thornhill, Yorkshire, on the 9th September, 1947

THE RIGHT HONOURABLE HUGH GAITSKELL, C.B.E., M.P.,
Minister of Fuel and Power.

10 May, 1948.

SIR,

I.—INTRODUCTORY

1. In compliance with your direction, I have held a Formal Investigation under the provisions of Section 83 of the Coal Mines Act, 1911, and under the Ministry of Fuel and Power Act, 1945, into the causes of, and circumstances attending, the explosion at Ingham Colliery, Thornhill, Yorkshire, on the 9th September, 1947, causing the loss of 12 lives and injuries to one person. I have now the honour to submit my report.

2. By kind permission of the Mayor and Corporation of Dewsbury, the Inquiry was held in the Council Chamber of the Town Hall, Dewsbury, from the 11th to the 14th November, inclusive, and I desire to record my appreciation of their assistance in placing such suitable accommodation at my disposal.

3. The appearances at the Inquiry were as follows :—

(a) *Ministry of Fuel and Power*

Mr. H. J. Humphrys, H.M. Divisional Inspector of Mines.

Mr. E. S. Rees, H.M. District Inspector of Mines.

Mr. G. M. Harvey, H.M. Electrical Inspector of Mines.

Dr. H. F. Coward, Director of Safety in Mines Research and Testing Branch.

(b) *National Coal Board*

Mr. J. Hunter, Production Director, North Eastern Division.

Mr. C. H. M. Glover, Legal Adviser, North Eastern Division.

Mr. H. M. Hudspeth, Deputy Production Director, North Eastern Division.

(c) *National Union of Mineworkers*

Mr. J. A. Hall, President, Yorkshire Area.

Mr. J. H. Scargill, Secretary, Thornhill Branch.

(d) *British Association of Colliery Management*

Mr. A. S. Furniss, Solicitor.

(e) *National Association of Colliery Managers*

Mr. A. Holdsworth, President, Yorkshire Branch.

(f) *Yorkshire Deputies Association*

Mr. J. Howard.

4. A list of the 25 witnesses examined during the course of the Inquiry is given in Appendix I, and a list of the persons killed and injured in the explosion is given in Appendix II.

II.—GENERAL INFORMATION

5. Ingham Colliery is situated within the boundaries and on the south side of the County Borough of Dewsbury in West Yorkshire, and has been producing coal since about 1860. It is connected underground to Combs Colliery and there is also a surface connection by a tramway along which the coal produced at Combs is hauled to the screening plant at Ingham. Part of the underground ventilation system is common to both mines. Despite their surface and underground connections and the partly common system of ventilation, Ingham and Combs are worked as separate mines, being divided by properly delineated boundaries, under Section 25 of the Coal Mines Act, 1911.

6. At Ingham Colliery there are two coal winding shafts, the No. 1 downcast, 13 feet in diameter, and the No. 2 upcast, 14 feet in diameter. Both shafts were sunk to the Black Bed Seam at a depth of 277 yards, and each has an inset at 188 yards in the Beeston Seam. An output of 180 tons from the Black Bed and Blocking Bed Seams was wound daily from the Black Bed level in No. 1 shaft, and an output of 450 tons from the Beeston and Wheatley Lime Seams was wound daily from the Beeston Seam inset in the No. 2 shaft, giving a total daily output for the colliery of 630 tons, 80 per cent. of which went to the coke ovens. The Wheatley Lime Seam has been worked for the past 85 years so that its characteristics were well known. It yields a coal for coking and industrial use.

7. At Combs Colliery the downcast shaft is 11 feet in diameter and is sunk to the Black Bed Seam at a depth of 369 yards. The daily output from this shaft is about 140 tons per day. From an inset in this shaft in the Beeston Seam at a depth of 224 yards, a road driven in the seam forms the intake for the No. 2 South District, Wheatley Lime Seam, Ingham Colliery—the district in which the explosion occurred. There is also a pumping shaft at Combs, 12 feet 6 inches in diameter, sunk to the New Hards Seam, at a depth of 106 yards, from which there is a connection to a staple pit sunk to the Blocking Bed Seam. These water pits are not used in connection with the working of the mine, apart from drainage purposes.

8. The ventilation was produced by a steam-driven Walker fan, 7 feet in diameter, situated on the surface at the Ingham upcast shaft, and passing 140,000 cubic feet of air per minute at a water gauge of 3.6 inches. Safety lamps were used throughout. The types of lamp provided for general underground use were Ceag 2-volt electric cap lamps and Ceag 4-volt electric hand lamps. For gas testing, the workmen were issued with Davis-Kirkby flame safety lamps, magnetically locked, and the officials used the Prestwich type No. 6 flame safety lamps, fitted with internal relighters and lead rivet locks. To meet the requirements of the General Regulations in respect of precautions against coal dust, and to facilitate systematic cleaning-up, stone-dusting and sampling, the roadways were apportioned in numbered zones. Gypsum dust was used for stone dusting throughout the colliery. The amount used was a little over 2½ lb. per ton of coal output.

9. The Agent and Manager of Ingham Colliery was Mr. E. E. Cleaver. The Under-manager for the No. 1 Pit was Mr. C. Walshaw, and for No. 2 Pit, Mr. B. Aston. Mr. Cleaver was also agent for Combs Colliery, which had a separate manager but no under-manager. There were no overmen at either colliery, the deputies coming directly under the under-manager. Mr. Cleaver came under the direction of the Area General Manager, Mr. J. Scoular who, in turn, came under Mr. H. M. Hudspeth, the Deputy Production Director and Mr. J. Hunter, Production Director for the North Eastern Division of the National Coal Board.

10. It is perhaps proper to recall that there is a history of firedamp in this area for, in the year 1893, an explosion of firedamp occurred at the bottom of the Combs downcast shaft, by which 139 persons lost their lives. The shaft was then sunk only to the Blocking Bed Coal at a depth of 165 yards ; but the seam being worked at the time was the Wheatley Lime, which was entered from an inset 34 yards higher up the shaft across which a wooden staging had been fixed, leaving a four-foot space at one side for the passage of air down to the Blocking Bed seam. Safety lamps were used throughout, except in the immediate vicinity of the shaft where six open paraffin lamps were used to illuminate the shaft inset. A joint report on this disaster was made by the late Mr. F. N. Wardell, H.M. District Inspector and the late Sir Henry Hall, who concluded that firedamp accumulated below the staging and communicated with a feeder of firedamp behind the brick shaft walling. The gas was ignited by one of the open paraffin lamps. The explosion was mild and not extensive. The heavy death roll resulted from suffocation by smoke from the wooden fittings in the shaft and the wooden staging at the Wheatley Lime seam inset, which had been set on fire by the explosion. The shaft passed through a fault and an attempt had previously been made to pipe the gas made there to light the inset. Gas had, however, been ignited at this point some months before the explosion.

11. The area of coal in the Wheatley Lime Seam in which the present explosion occurred was opened out some years ago from two stone drifts driven from the Beeston Seam, through a 40 yards downthrow fault. One drift was driven at an inclination of 1 in 7 in line with, and as a continuation of, the Evison Bord in the Beeston Seam, and this roadway was used as a return airway, travelling and haulage road to the workings in the Wheatley Lime Seam. The other drift, which was used as the intake airway, was driven at an inclination of 1 in 2. The extent of the workings in this area from that time until the explosion is shown in Plan No. 2.

12. The seam is 2 ft. 11 ins. thick and the immediate roof is a strong bind with well-defined bedding planes. The floor is a hard fireclay. The only district working at the time was the No. 2 South. The method of working was advancing longwall with gates at each extremity of the face, which served as the intake and return airways. Three dummy gates were also driven to provide material to pack the waste. The face at the time of the explosion was 140 yards in length. The coal was undercut by longwall coal cutters to a depth of 4 ft. 6 ins. and was loaded on to a face conveyor which discharged to a conveyor in the return gate known as South 2 Conveyor Gate. Belt conveyors in tandem in this gate delivered the coal to a conveyor on the main haulage road which discharged the coal into tubs at a loading point near the top of the 1 in 7 drift. From this point the coal was hauled to the No. 2 upcast shaft in tubs of $4\frac{1}{2}$ and $6\frac{1}{2}$ cwt. capacity by an endless-rope haulage running at $1\frac{1}{2}$ miles per hour. The first 1500 yards of this haulage road was the Evison Bord, including the 1 in 7 drift. Then, 500 yards from the shaft the haulage passed round a right-angle bend into the South Ending, where it received coal coming from the South Districts in the Beeston Seam. Thus the haulage and conveyor roads were all in the return airway, which was also the travelling road into the No. 2 South District. The deputies' meeting station (*see* Plan No. 2) was near the top of the 1 in 7 drift and was also in the return airway. Throughout the district, the conditions generally were slightly damp and water collected at certain parts and had to be pumped outbye. Electricity was used for operating coal-cutters, conveyors, pumps, drills for coal and stone, signalling system and for the telephone circuit, which extended almost to the working face.

13. As previously indicated, the intake air to the No. 2 South District came from the Combs shaft by way of a roadway in the Beeston Seam. This roadway,

although small in parts was, nevertheless, well regulated. The intake air then passed up the 1 in 2 drift parallel to the 1 in 7 return drift through the 40-yard fault and thus entered the Wheatley Lime Seam. A statutory air measurement taken at the top of the intake drift on 26th August, 1947, a fortnight before the explosion, showed 15,500 cubic feet of air per minute to be entering the district. Other air measurements, however, showed that of this quantity only 5,950 cubic feet reached the face of No. 2 South, so that leakages—which occurred mainly at three points—were very heavy and will be referred to later in more detail.

14. On the 5th June, 1947, the No. 2 South Face was 185 yards in length. At that time the right hand side of the face extended 30 yards beyond the No. 2 South Conveyor Gate to a fault (which was being stripped at that time). The left side of the face extended for a shorter distance beyond the intake airway tail gate. In this 30 yards of face between the No. 2 South Conveyor Gate and the fault, a subsidiary tail gate was packed 9 yards from the fault side. On the 5th June, 1947, when the third and last of a series of ripping shots was being fired in this subsidiary tail gate, firedamp was ignited in a break which crossed the shot-hole and the flame passed 64 yards back along the side of the fault. In consequence, the face was shortened in order to concentrate and improve the ventilation, and a 9-inch brick wall, with a two-yard dirt pack on the outside of it, was built in the crossgate to seal off the subsidiary tail gate. The ignition of gas was investigated at the time by H.M. Inspectors of Mines and Officers of the Safety in Mines Research and Testing Branch. Following the present explosion, which blew the 9-inch brick stopping and the two-yard pack inwards towards the fault, the locality was again inspected by the same investigators to see if the previous ignition of gas had any bearing on the present explosion, but it was considered that there was no connection between the two events.

III.—THE EXPLOSION AND EVENTS LEADING UP TO IT

15. The explosion occurred in the No. 2 South District of the Wheatley Lime Seam on Tuesday, 9th September, 1947, at 11.15 p.m. during the first hour of the night shift. The number of persons normally employed during the 24 hours in this district was 105 but, owing to a wages dispute, the No. 2 South Face had not been filled off since the previous Friday and, in consequence, the normal sequence of work was interrupted.

16. On the day shift of the 9th September, men other than the usual colliers were employed filling coal off the face and boring shot-holes in the coal as the filling proceeded. At the end of the shift, however, there were 30 to 40 yards of face still to fill off. Other workmen were employed in enlarging the intake airway near to, and on the outbye side of, the Gledhill Crossgate (*see* Plan No. 2), and one man was attending the pump in the intake tail gate. Apart from a broken belt, which was repaired, in the outbye conveyor in the South 2 Conveyor Gate, the shift was uneventful.

17. On the afternoon shift, five men were at work erecting bars at the face of the South 2 Conveyor Gate and one man was again attending the pump. Seven others were engaged enlarging the intake at a point near Old North 2 District. The deputy on this shift said he made tests with his flame safety lamp for firedamp at numerous points in the district but found none. He ascended the shaft at 10.30 p.m. with the five men who had been working in the South 2 Conveyor Gate, leaving the district, so far as he knew, in perfectly normal condition and certainly not anticipating danger of any kind, let alone the disaster which was to follow so soon afterwards. The remainder of the men on the shift had left the mine about an hour before the deputy.

18. The night-shift for the South 2 District consisted of 13 persons, 12 of whom perished in the explosion. The one survivor, Jesse Clarke, a shot-firer, was discharged from hospital on 5th November, 1947, apparently fit and unharmed, apart from the scars of burns, but unfortunately suffering from a loss of memory and quite unable to remember anything of the events of the tragic night. Had he been able to recall what happened, he would have been a most valuable witness and would undoubtedly have shed light on many points which arose at the Inquiry when various witnesses were endeavouring to explain the course of events that night.

19. The night-shift deputy, F. W. Pearson, two shot-firers, Bernard Hewitt and Jesse Clarke, and two beltmen, Arthur Wilson and Clifford Howarth, descended the mine at 10 p.m. This was half-an-hour before the normal time for the descent of the night-shift proper. At 10.5 p.m., before proceeding inbye, Pearson consulted with his opposite number on the afternoon shift. About 10.15 p.m. workmen on the afternoon shift, while on their way outbye from the No. 2 South District, met Pearson and his men at the outbye end of the Evison Bord on their way inbye to work. The beltmen, Wilson and Howarth, had been instructed to run the conveyor belts and, after the explosion, their bodies were found in the position they would have occupied had they been performing this task. The switch in the switch-box controlling the conveyor motor was found in the "on" position but a pilot switch alongside one of the dead men was in the "off" position. It is possible that the men may have had time to open the pilot switch. On the other hand, the conveyor may not have been started up. What exactly happened will never be known, but, in my opinion, the question is not material.

20. The dead bodies of deputy Pearson and shot-firer Hewitt, and the unconscious Clarke, were found after the explosion at the deputies' meeting station near the top of the return drift. The time required to walk from the shaft bottom to the meeting station was 25 to 30 minutes so that these three officials may have arrived there about 10.30 or 10.35 p.m. Their movements after arrival are a matter of deduction and to some extent of surmise. It is unfortunate that this is so, since these movements are vital to the correct explanation of what happened on the night of this explosion. It is known, however, that deputy Pearson telephoned from the meeting station to the night onsetter, Herbert Collomosse, in the shaft bottom at a time which Collomosse put at 10.50 p.m. It was an inquiry as to the number of persons on the regular night-shift, which descended the shaft at 10.30 p.m., and who were coming to work in the No. 2 South District in the Wheatley Lime Seam. The conversation, however, extended to general topics and did not conclude until 11.5 p.m. Collomosse said Pearson sounded very cheery and certainly not like a man who had any thought of impending danger. Immediately after his talk with Pearson, Collomosse received a telephone call from a deputy in another district who also inquired about the number of night-shift men likely to proceed to his district. This conversation finished about 11.10 p.m.

21. What followed soon after that is best described in the words Collomosse used at the Inquiry. "Well, at 11.15 p.m., there was a thud. That was the time it happened as far as I can say. I went out of the office and looked round the pit bottom, and I could see there was something unusual had happened. There were clouds of smoke and things coming into the pit bottom which should not have been." After unsuccessfully trying to get into communication with the inbye districts, he then telephoned to the surface to raise the alarm.

22. Four night-shift byeworkers were travelling the South Ending when the explosion occurred. They had reached a point about 350 yards from the upcast shaft, where two doors led into an intake airway along which they customarily

travelled to their work in the Beeston Seam. One of these byeworkers in giving evidence at the Inquiry said he saw "a terrible flash" and heard a report, and he was thrown a distance of 5 or 6 yards. He described how the air became so thick with smoke and dust that he could not see his hand before him as he stood upright. It was very hot but it was clearer and cooler near the floor. After that, he and his mates pulled themselves together and assisted each other through the doors into the intake where the air seemed to be stagnant but quite clear. They then travelled outbye along the intake and through the separation doors to No. 2 Shaft. A deputy, who was at West Bord 3 in the Beeston Seam intake 480 yards inbye from the junction of the Evison Bord with the South Ending, said that at the time of the explosion he noticed a "swell of dust" which blew open separation doors between the intake and return. This deputy also stated that he parted from deputy Pearson and his two shot-firers at the junction of the Evison Bord at 10.15 p.m., as they proceeded on their respective ways, thus establishing the time when Pearson and his mates left the junction of the Evison Bord with the South Ending.

23. The night-shift proper for No. 2 South District in the Wheatley Lime Seam descended the shaft about 10.30 p.m. and consisted of eight persons. They were still on their way inbye and were travelling up the 1 in 7 Drift, but had not reached the meeting station, when the explosion occurred. They met its full violence and were all instantly killed by it. This brought the toll of the explosion to twelve killed and one injured.

IV.—EXPLORATION, RESCUE AND RECOVERY OPERATIONS

24. Mr. B. Aston, Under-Manager of No. 2 Pit, arrived at the colliery about 11.45 p.m. on the night of the explosion and was told by the Manager that smoke was coming from the fan drift. He descended the No. 1 downcast shaft and saw a number of workmen, from districts other than the No. 2 South in the Wheatley Lime Seam, congregated in the office near the bottom of the upcast shaft. He withdrew them into the intake, which he then proceeded to explore with a small party of deputies and workmen. On arriving at the separation doors about 350 yards inbye from the pit bottom, they found both doors damaged, the one nearest to the return airway being the most seriously damaged. They temporarily repaired one of the doors and then proceeded along the intake to the separation doors near the outbye end of the Evison Bord. They found these doors completely blown out and considerable smoke and fumes issuing from the Evison Bord. Realising that the explosion had occurred in the No. 2 South District of the Wheatley Lime Seam, the Under-Manager saw at once that exploration of the district at that time by way of the Evison Bord was impossible. He returned to the shaft and ascended to report the position to the Manager, leaving instructions with the deputies to erect brattice sheets in the connection between the intake and return at the outbye end of the Evison Bord.

25. After consultation, it was decided to explore by way of the intake airway to the district from the Combs shaft, and at 1.40 a.m. on the 10th September, Mr. Aston, accompanied by Mr. I. Keeton, Assistant Superintendent of the Wakefield Rescue Station and a Rescue Brigade, descended Combs shaft and reached the stricken district by way of the intake airway. Although apparently undamaged by the explosion, this intake airway was not a good travelling way because of low height, rough floor, and the steepness of the 1 in 2 intake drift. On reaching the slit between the intake and return just beyond the intake drift, they found the two separation doors and their frames completely blown out in a direction away from the return airway. In travelling through the slit they thought they heard a moan and on going forward they

found Jesse Clarke, the shot-firer, in the return haulage and travelling road with his head resting on the full-side rope (the side remote from the intake) which was elevated a little from the floor. It was then about 2.10 a.m., or about three hours after the explosion. The reason for Clarke's survival has probably an important bearing on the cause of the explosion and will be more fully discussed later in this Report. The Rescue Brigade coupled up and brought Clarke out into the intake, where he received first-aid and was kept warm. They went back again and in the slit beyond the haulage road at the meeting station from which deputy Pearson had conducted his last telephone conversation, and within a few yards of the position where Clarke was found, they recovered the bodies of Pearson and the shot-firer, Hewitt. Mr. Keeton then returned to the surface for first-aid material, blankets, brattice cloth and to summon further assistance, including another Rescue Brigade, as there was no means of telephonic communication available. He returned to the fresh air base at the top of the intake drift about 3 p.m. To restore the normal ventilation circuit, brattice sheets were then erected in the slit already mentioned between intake and return and in the next slit further inbye, where the stoppings had been blown out. The party then explored further inbye along the intake to the inbye end of the Evison Bord and then back along the Bord to the junction of South 2 Conveyor Gate, where they found the dead bodies of the beltmen, Wilson and Howarth. They found the doors and brattice sheets erected in the continuation of the Evison Bord beyond the junction with the South 2 Conveyor Gate had also been blown out and in an inbye direction. Meantime, the sole survivor, Clarke, had been wrapped up and transported to the surface and thence to the hospital.

26. In continuance of the work of restoring the normal ventilation, a start was made to erect sheets in the Evison Bord beyond the junction with South 2 Conveyor Gate. While this was in progress Mr. Keeton went outbye to obtain still more assistance. At the second inbye slit, he met a party consisting of Mr. H. J. Humphrys, H.M. Divisional Inspector of Mines, Mr. I. G. E. Leek, H.M. District Inspector and Rescue Apparatus Testing Officer, Mr. H. M. Hudspeth, Deputy Production Director, and Dr. H. L. Willett, Head of the Safety and Research Department of the North Eastern Division of the National Coal Board. This party had descended the Combs shaft at 6.15 a.m. and had reached the district by way of the intake airway. On passing through the second slit to the Evison Bord they detected a trace of firedamp, rising to about 3 per cent. at the entrance to the old road opposite and on the far side of the Evison Bord. They also detected about 3 per cent. firedamp at the outbye end of South 2 Conveyor Gate. They returned to the intake, and at a point on this roadway about 30 yards inbye of South 3 they encountered a fall which blocked their way, although a small quantity of air was passing through. It was then about 7.30 a.m. The Under-manager was left at this fall with instruction to get a travelling road made through it and the party returned to the outbye end of South 2 Conveyor Gate, where the firedamp content gradually diminished to 1 per cent. as the quantity of air passing increased. About this time Mr. J. Hunter, Production Director, Mr. W. E. Jones, Secretary of the Yorkshire Area of the National Union of Mineworkers, and Mr. Cleaver, the Colliery Agent and Manager, arrived. After consultation, an exploration of South 2 Conveyor Gate was undertaken by a party, some of whom were not wearing rescue apparatus although, as it turned out—despite the fact that the canary carried by Dr. Willett was not affected—the percentage of carbon monoxide in the air proved to be harmful, for several members of the party suffered slightly from carbon monoxide poisoning and the party was forced to retire. Their exertion, and hence their breathing, must have been heavy, due to the roadway being badly obstructed by falls several feet in height.

27. In the meantime, another party, under the charge of Mr. J. G. Bond, Deputy Area General Manager, and accompanied by Mr. M. McCarthy, H.M. Assistant Inspector of Mines, and two rescue brigades under the charge of Mr. C. C. Riley, Superintendent of the Brierley Rescue Station, commenced an exploration of the Evison Bord from the outbye end. They descended the No. 1 downcast shaft at Ingham Colliery at 9.45 a.m. on the 10th September, and travelled inbye by way of the intake airway until they reached the recently erected sheets which replaced the separation doors destroyed by the explosion at the outbye end of the Evison Bord. On passing through the sheets into the Evison Bord, they were unable to detect firedamp, and the canary carried by the party was not affected. On travelling up the Evison Bord they found the dead bodies of five men near the bottom of the 1 in 7 drift which was heavily fallen. They were unable to find the bodies of the other three victims, which were recovered later in the day farther up the drift under heavy falls which almost blocked the entire roadway near the top of the drift. Rescue Station Superintendent Riley, after working in the drift for three hours without rescue apparatus, felt giddy and had heart palpitation, although the canary beside him showed no signs of being affected.

28. With the restoration of the ventilation and travelling conditions in the affected area, careful examination was made of the district by experts on behalf of the Ministry of Fuel and Power, the National Coal Board and the National Union of Mineworkers. Careful notes were made of conditions as found following the explosion and are shown in some detail on Plan No. 1. I, personally, made an underground inspection of the scene of the disaster, accompanied by representatives of H.M. Inspectorate, the National Coal Board and the National Union of Mineworkers.

29. Dr. F. V. Tideswell of the Safety in Mines Research and Testing Branch of the Ministry of Fuel and Power made a particularly careful survey of the area affected by the explosion and examined a large number of specimens collected by himself and others for indications of burning. Where appropriate, the specimens were also subjected to chemical analysis or other examinations. As a result, positive signs of burning were observed at a point on Evison Bord haulage road, 200 yards from the outbye end, and thence inbye along the road to its junction with South 3 disused conveyor road, a distance of about 1,500 yards; on South 2 Conveyor Gate to the face, a distance of 600 yards; on South 2 longwall face, 120 yards; along the left intake tail gate, 350 yards; on Gledhill Crossgate, 140 yards; along the intake between Gledhill Crossgate and Evison Bord; and along the intake airway outbye the Evison Bord to a point about 100 yards short of the right-hand gate of North 1 District. He also found signs of burning in parts of the disused districts between South 2 Conveyor Gate and Evison Bord. He considered that these signs of burning indicated that the flame of the explosion traversed a distance of over 3,000 yards. In his view the explosion developed moderate violence on South 2 Conveyor Gate where there were heavy falls of ground and damage to the conveyors, and on the Evison Bord where there were heavy falls on the 1 in 7 Drift, and tubs were badly damaged. Elsewhere the explosion was mild in character and the damage was not great.

V.—CAUSE OF THE EXPLOSION

30. All the expert witnesses to the Inquiry were of the opinion, and I agree, that the explosion started as a substantial explosion of firedamp. Two questions arise. What was the source of ignition? How did there come to be an accumulation of firedamp? I will deal with these two questions separately.

(a) Source of Ignition

31. During the course of the Inquiry only one possible source of ignition was put forward. It was the Prestwich type 6 flame safety lamp No. 9, fitted with an internal relighter and locked with a lead rivet. This lamp was issued to Bernard Hewitt, the shot-firer, before he descended the shaft at 10 p.m. on the night of the explosion. After the explosion, the lamp was found in two parts. The oil vessel, an opened pocket knife, and two portions of a lead rivet were found close to the telephone at the meeting station where Hewitt's body was found. The top of the lamp was found on the haulage road close to where the body of Deputy Pearson was found. Both parts of the lamp, the two parts of the lead rivet and the open knife were within 5 or 6 yards of Hewitt's body.

32. The lamp, lead rivet and knife, as found, were submitted to Mr. C. B. Platt, Superintending Testing Officer for the Ministry of Fuel and Power, and he submitted a report to the Inquiry with the following conclusions :—

(1) There is as factual evidence :—

- (a) The lamp was received in two parts and unlocked.
- (b) The lamp frame passed flame when the relighter was operated in air containing firedamp. (*Note* : Under cross-examination the witness said no adjustment was made to the relighter before the test.)
- (c) Owing to the design of the lamp, the spirit vessel could not be removed from the lamp without extinguishing the lamp flame in the process.
- (d) The screw threads between the lamp frame and the spirit vessel were in good condition and free from damage by force.
- (e) The spirit vessel could not be replaced on the lamp frame in the condition of receipt, as the wick tube was bent.
- (f) The wick tube could not have been bent whilst the spirit vessel was assembled on the lamp.
- (g) The dust in and which completely filled the grooves of the screw threads of the spirit vessel contained traces of coked particles of coal dust ; this dust could not have accumulated in the screw threads to the extent observed if the vessel had been assembled on the frame prior to and during the explosion.

(2) As circumstantial evidence, there is :—

- (h) The presence of an open jack-knife which was stated to have been found near the lamp.
- (i) The remains of a lead rivet also stated to have been found in the vicinity of the lamp.

The conclusions to be drawn from the evidence are that :—

- (i) The spirit vessel must, of necessity, have been removed from the lamp frame prior to the explosion and that it was removed by unscrewing it and not by force.
- (ii) The lamp would have ignited firedamp if the relighter were operated in an inflammable atmosphere whilst the spirit vessel was removed from the lamp frame for, in a test, the spark of the relighter ignited the firedamp and flame passed through the wick tube sleeve into the outer atmosphere.
- (iii) The fact that an open jack-knife and the remains of a lead rivet were found near the lamp is significant but the tests to establish that the knife had been used to cut the rivet were inconclusive, nor could it be established that the lead rivet was, in fact, the rivet with which the lamp was presumably locked when it was issued for use.

33. All the other lamps, flame and electric, in use in the district were carefully examined. Two only were damaged but as they were found in places where it was considered the damage was the result of the explosion, they were not considered to be possible sources of ignitions.

34. The electric plant came under suspicion in the early stages of the examination of the district since it was known that current was on the cables when the explosion occurred and at least one switch-box was damaged. The telephone system extended almost to the face along the South 2 Conveyor Gate and the possibility that it might have been in use when the explosion occurred was considered, although the inner length of the telephone system was controlled by a switch which was probably open at the time.

35. Mr. R. L. Parker, H.M. Assistant Electrical Inspector of Mines, said in evidence that, in conjunction with officials of the National Coal Board, he had spent 26 days in the inspection and testing of the electrical apparatus in the area traversed by the explosion. There were 130 items of electrical equipment in use in the district, all of which had been examined underground and most of which were later brought to the surface for further special and exhaustive test. Further, the telephones and signalling apparatus from the district were tested and reported upon by the appropriate officers of the Ministry's Safety in Mines Research and Testing Branch. The conclusion reached was that the electrical equipment, including telephones and signalling apparatus, was very well installed and maintained and that it had played no part whatever in originating the explosion.

36. Other possible sources of ignition were examined, and, in particular, reports were made by specialist officers of the Ministry's Safety in Mines Research and Testing Branch on the possibilities of ignition by (i) the flame of the June ignition which might possibly have continued to burn feebly at a feeder coming into a roof break or cavity and (ii) the friction of falling rock at the coal face or elsewhere. As the opinions expressed in the reports were negative, no evidence was called in respect of them.

37. Having carefully considered the evidence, and being satisfied that all other sources of ignition could be eliminated, I have no hesitation in finding that the source of ignition was the operation of the relighting device of flame safety lamp No. 9, after the lamp had been taken apart, probably because the relighter was not working properly and needed adjustment. To open a safety lamp anywhere underground at this colliery, and especially in the return airway, was a grave misdemeanour and a serious contravention of Section 34 (1) (iii) of the Coal Mines Act, 1911, as amended by S.R. and O. 1927, No. 1155. There is, however, no evidence to show who opened the lamp or who then operated the relighter.

(b) *Accumulation of Firedamp*

38. There were among the witnesses two conflicting schools of thought as to how there came to be in the workings an accumulation of firedamp at explosive point. The evidence is wholly circumstantial, but before I examine this in detail it is important that it should be realised that any explanation to be true must be consistent with the following facts :—

(i) The accumulation of gas was large.

(ii) It was brought about quickly, certainly in less than an hour, and most likely in about half an hour.

(iii) It was present at explosive point in the general body of the air current of the order of 15,000 cubic feet per minute, passing the meeting station when the relighter of the open flame lamp was operated there and started the explosion.

39. There was no suggestion at all that the seam was liable to outbursts of firedamp and no evidence of any such disturbance of the strata, e.g. in the wastes, as might have forced any large body of firedamp suddenly into the air current. The only considerable body of firedamp known to exist in the whole of the area concerned was a large accumulation in the Old North 1 District (*see* Plan No. 2), which finished in December, 1945. The one school of thought associated the explosion with this accumulation of firedamp: the other school with firedamp not known before the explosion but suspected afterwards to have bled off very freely from the fault which formed the boundary of the South 2 District on the right-hand side up to the time of the ignition of firedamp which occurred there in June, 1947. I am in general agreement with the first school of thought and shall now examine the evidence and give my considered reasons.

(c) *Accumulation of Firedamp in Old North 1 District*

40. This old district was situated alongside the intake airway as it entered the Wheatley Lime Seam and was entered by two roadways branching off at right angles from the intake. When the district was at work, air was caused to circulate in it by two doors erected in the main intake airway between the two roads. With the doors closed, the air passed up the left-hand road round the face and down the right-hand road, after which it ventilated the other workings inbye. It was, therefore, what is sometimes called "shunt ventilation"—a system which has serious disadvantages. It would have been far more satisfactory if an air-crossing had been built and the district separately and continuously ventilated. After the Old North 1 was finished, the door frames and settings remained in position in the intake airway, but the doors were lifted off their hinges and placed against the side of the airway, one immediately inbye each of the door frames.

41. After the explosion, the outbye door was found in the position just indicated but the inbye door was broken into many pieces scattered along the road inbye of the door frame. Photographs of the broken door were produced at the Inquiry and also of the door frame and setting. The sill of the door frame was made in three sections. Two of these were found turned over in an inbye direction, obviously by the fracture of the door, for a section of the broken door exactly corresponded in width with the two turned over sections of the sill. Moreover, the hanging post of the door frame was broken in half, and a piece of the door was found attached to the hook on each half of the door post.

42. Mr. E. S. Rees, H.M. District Inspector of Mines, expressed the opinion that the firedamp which caused the explosion was forced out of old North 1 District by the closing of the inbye door in the intake airway between the two roads. He considered the door was closed on the night-shift within 30 to 35 minutes of the occurrence of the explosion. Dr. Tideswell of the Ministry's Safety in Mines Research Branch held the same view, except that he considered the door was only partly closed. Both considered that the inbye door was hanging in the intake airway when the explosion occurred and that it was broken into the condition in which it was found by the blast of the explosion.

43. A good deal of evidence, much of it contradictory, negative, inconclusive and unsatisfactory, was given about these doors. The management admitted that for a few months after North 1 District was stopped in 1945, the doors were used from time to time to force air round the district whilst plant and materials were being withdrawn from it, but they disclaimed any knowledge of their subsequent use. Following the removal of the plant and materials, they said the doors were lifted off their hinges and were placed against the side of the intake airway and that they remained there month after month,

apparently not being required for use elsewhere. So far as is known, the last living persons to travel the intake airway past the doors, before the explosion, was the party of backshift workmen who had been engaged in the enlargement of the intake airway near the Old North 2 District. They passed the position of the doors about 9 p.m. on their way outbye at the end of their shift. Two were called as witnesses. Strangely enough, they both said quite positively that they did not see any doors at this point, either standing at the side of the airway or hanging on posts.

44. Evidence of a hearsay nature was given by a deputy who had at one time been employed in this district, that one of the doors had been badly damaged when a coal-cutting machine, which had been brought out of North 1 District, was being pulled along the airway by means of a sylvester. If the door had been damaged in this way it must, of course, have been hanging on the post at the time. Evidence was also given by a coal-cutting machineman that the door was damaged by a coal cutter when he used the door as a ramp when hauling the machine over a dint in the floor. I got the impression that this witness was confused as to the actual place where this event happened. In any case, however, as explanations for the damage to the door as found after the explosion, the evidence of both witnesses can be completely discarded, for the events described were said to have occurred many months before the explosion and there was reliable evidence that the door, while perhaps not in thoroughly good order, was in a fit state to be used shortly before the explosion. Furthermore, I put a question to the Under-Manager, Mr. Aston, about the incidents with the coal-cutting machine.

Q. Could you conceive that operation could smash the door into the condition in which it now is ?

A. Well, no.

45. Mr. Aston saw the inbye door at 10.15 a.m. on the day of the explosion. He said the doors were leaning against the left-hand or high side of the airway, each a little *inbye* its particular door frame. The inbye door was then "more or less bent in the middle and frayed at the top" but it was not damaged to the extent as found after the explosion. The day-shift deputy, A. B. Allport, said the inbye door was only "slightly damaged" when he saw it during the course of his shift on the day of the explosion. The two door frames were undamaged. On the other hand, the deputy, C. Barber, on the afternoon shift on the day of the explosion, said the outbye door was on the outbye side of the frame but that the inbye door was broken into three pieces and about one-quarter was missing altogether. One piece of this door was on the left-hand side of the road and two on the right-hand side, all on the *outbye* side of the door frame. He went further and said that he had noticed the door in this condition from the Thursday prior to the explosion. This evidence was uncorroborated and completely at variance with that of Aston and Allport, and I am unable to accept it.

46. The doors when hung, opened in an outbye direction and it was generally agreed that if either or both were closed or nearly closed, firedamp would be forced out of the disused No. 1 District. Mr. E. E. Cleaver, Agent and Manager, and Dr. H. L. Willett, the scientific expert witness for the National Coal Board, both accepted the view that if the inbye door had been closed or partly closed at the time of the explosion it would have sustained damage very similar to the damage it had in fact sustained when seen after the explosion. Moreover, Dr. Willett agreed that the damage to the door was not inconsistent with the door being hung in position at the time of the explosion.

47. The question which now falls to be considered is whether firedamp in sufficient quantity to account for this explosion could be driven out of the old

North 1 District by the closing or nearly closing of the inbye door by someone on the night-shift, as was suggested by Mr. Rees and Dr. Tideswell. Whilst he could not conceive of Pearson, Clarke or Hewitt closing the door in the prevailing circumstances, Mr. J. Hunter, Production Director, who led for the National Coal Board, put a number of searching questions to several technical witnesses to the effect that a very careful scrutiny of the time factor would show that, in any event, there seemed to be insufficient time for the night-shift deputy or any of the other men who had arrived in the district shortly before the explosion, to close the door and effect the clearance from the old North 1 District of the necessary quantity of firedamp to account for the explosion. As already indicated, the deputy, Pearson, the two shot-firers, Clarke and Hewitt, and the two beltmen, Wilson and Howarth, were seen at the outbye end of the Evison Bord on their way inbye at a time estimated to be 10.15 p.m. This point was just short of a mile from the meeting station. A very comfortable walking rate underground is twenty-five minutes to the mile. There seems no reason why Pearson and his party should not have reached the meeting station by 10.40 p.m., which was ten minutes before Pearson commenced his telephone conversation with the onsetter, Collomosse, and thirty-five minutes before the explosion occurred. If, on arrival at the meeting station, Pearson wanted to force some air round old North 1 District by fixing the door, which was only a minute's walk from the meeting station, he had plenty of time to go round with one of the shot-firers and do so, and be back at the meeting station in time for his telephone talk with Collomosse. After the completion of the talk, there was time to go back to the door and observe the effect. The vital question is whether this, or something like it, actually occurred. This is where evidence from Jesse Clark, if he had been able to remember what happened that night, would have been of great assistance.

48. A note from the Under-Manager was found in the pocket of the deceased deputy, saying that the Manager intended to visit the district the following morning. The Under-Manager said he wrote the note with the object of ensuring that the deputy would make "the district look a little bit better." He thought the effect on the deputy would be "to carry the order out and get everything straightened up." It was known that there were considerable quantities of firedamp in the two roads leading into Old North 1 District, with more in the inbye road than in the outbye road, probably because of the regulator effect of the door frames. On November 4th, when I made an underground inspection at the colliery, the firedamp was in explosive proportions from roof to floor at a distance of $57\frac{1}{2}$ yards from the side of the intake airway in the inbye or right-hand road in Old North 1 District, and at a distance of 130 yards from the intake in the outbye or left-hand road, the original intake to Old North 1 District. On September 22nd, it was necessary to travel up the right-hand road for a distance of 200 yards before encountering a similar mixture of firedamp. What was the condition of these roadways in Old North 1 District in respect of firedamp on the night of the explosion? Was the right-hand road full of gas? If so, the deputy would almost certainly wish to move it and the means most readily at hand was to hang one of the doors and close or nearly close it. He would know the obligation to keep the roadways clear of firedamp on the outbye side of the fences said to be erected near the road ends a few yards up from the intake airway, and to keep the intake to the working district free from inflammable gas up to a point within 100 yards from the face. Moreover, he would know that the returns had to be sampled regularly under the new Ventilation Regulations.

49. Because it seemed to be an action so contrary to what prudence and common sense would dictate, the representatives of the National Coal Board at the Inquiry suggested that officials with such a good reputation as the

deputy and the two shot-firers concerned would be incapable of such reckless conduct as to clear out firedamp from old workings, knowing it would foul the air current in which the incoming shift were proceeding to work, and then allow one of their number to produce a spark in this air current. The fact remains that one of them did open a flame safety lamp. This action cannot be condoned in any circumstances. I am doubtful, however, if any one of them was aware of all the circumstances or fully appreciated the possible results or consequences of hanging the door. In view of the lack of direct evidence, one can only speculate on the probable movements and actions of the three men during that fateful half-hour or so before the explosion. And there are many possibilities and even probabilities. It may be that deputy Pearson took Clarke with him to hang the door without telling Hewitt. They may have spragged the door partly open, expecting that sufficient air would pass along the intake to dilute to safe limits the firedamp driven out of the old workings, and the sprag may have subsequently fallen out. Once the door was fixed they may both have returned to the meeting station for the telephone conversation which the deputy probably expected would last only for a minute or two. It lasted instead for some fifteen minutes, after which the two men may have returned to the door to see the effect. They probably discovered that the fixing of the door had been more effective in clearing the gas out of Old North 1 District than they had expected. In the meantime, it may be that Hewitt, finding his lamp extinguished, possibly by firedamp, and being unable to relight it, decided to open it and examine the relighting device. Pearson may have returned at this moment, leaving Clarke behind. The relighter was tried, by whom no one can say, and the explosion happened. The part of the lamp containing the relighter was found near to Pearson, but the lamp was issued to Hewitt. Both men were killed, but as we have seen, Clarke survived. I do not think he would have been alive had he been in the position where he was found at the actual moment of the explosion. I think, therefore, that he was in the intake near the door and was about to return to the meeting station when the explosion happened.

50. The importance of the time factor has been mentioned and I have said that there was ample time for the fixing of the door. Consideration must now be given to see if there was time for the firedamp which would be driven out of the Old North 1, because of the fixing of the door, to reach the meeting station in explosive proportions. The last statutory air measurements prior to the explosion were made by Mr. Aston, Under-Manager, on the 26th August, 1947. They showed 15,500 cubic feet per minute in the intake at the top of the 1 in 2 drift and 5,950 cubic feet per minute in the intake at a point 100 yards back from the working face. There was, therefore, a leakage of 9,550 cubic feet per minute up to, and including, Gledhill's Crossgate. The leakage is excessive in amount but is of special significance when considering the distribution and composition of the firedamp-air mixture concerned in the explosion. It will be seen from Plan No. 2 that there were four connections between intake and return; but as there was a brick stopping in the second slit inbye from the top of the 1 in 2 drift, this slit was ruled out as a source of appreciable leakage. There were no measurements taken prior to the explosion to determine the extent of the individual leakages, but Mr. Aston, in evidence, estimated them in cubic feet per minute as 1,000 at the first slit, 3,000 at the end of Evison Bord, and 5,000 at Gledhill's Crossgate. On this estimate the fouled air leaking along Evison Bord would have to be charged with 25 to 30 per cent. of firedamp to be faintly explosive when, after dilution at South 2 Junction, it reached the meeting station, but the air passing down the intake and leaking along Gledhill's Crossgate need only contain 10 per cent. of firedamp to be just above the lower limit of inflammability when the combined leakages from Evison Bord and Gledhill's Crossgate reached the meeting station. Mr. Rees, in evidence,

estimated that the whole of the district would be fouled with firedamp in about half-an-hour from the time the door was closed but because of the leakages an explosive mixture might reach the meeting station in much less time depending on the degree of fouling of the intake. The air which leaked along the Evison Bord would only take ten or twelve minutes to pass from the intake just beyond the door—the fouling point—to the meeting station. Dr. Tideswell, who had carefully considered the question of the time required for an explosive mixture to reach the meeting station after the closing or partial closing of the door, put the limits as 6 minutes and 30 minutes, a time range that corresponds with the period between the time the deputy first arrived at the meeting station and the time of the explosion.

51. Dr. Willett, for the National Coal Board, resisted the theory that Old North 1 District was the source of the firedamp, largely because there was no sign of burning or violence observed in the intake on the outbye side of the old district. He advanced a theory, supported by three diagrams, the intention of which—as I understand it—was to prove that the door was not hanging in the intake between the two entrances to the old district at the time of the explosion and that, consequently, the source of the gas must be looked for elsewhere. His theory was based on the observed position of the firedamp in the two roads leading into the district on 22nd September and 4th November, respectively, indicating a build-up of firedamp of 143 yards in each road in six weeks. From these data and certain assumptions, he concluded that if the door had been in position the gas in the Old North 1 District would have been rounding the junction of the inbye entrance at the time of the explosion and that this gas would have been ignited and would have projected flame outbye along the intake, leaving signs of burning. I am unable to accept the validity of this reasoning. At best, negative evidence is unreliable when considering the passage of flame. No signs of burning were observed in the outbye slits between the intake and return although it is highly probable that flame passed through them. It is not possible to give the precise composition of the air in the intake immediately inbye of North 1 District at the moment the explosion occurred. It may not have been explosive. Even if it were, there was very little to register signs of burning in the length of intake in question.

(d) Firedamp from Fault bounding South 2 District

52. Mr. Cleaver, the Agent and Manager of the Colliery, and Dr. Willett, examined by Mr. Hunter, put forward the theory that the firedamp which caused the explosion bled off from the fault forming the boundary of the South 2 District on the right-hand side up to the time of the ignition in June. They said that normally this gas came into the South 2 Conveyor Gate and was diluted by the ventilation, but they contended that the fall in the part of the intake just inbye of South 3 gate (which had been formed by enlarging a length of working face that had been stopped) took place before the explosion and, in consequence, the ventilating current was reduced to a point where it was unable to dilute the firedamp. Dr. Willett considered that the quantity of air passing over the fall when he saw it a few hours after the explosion was about 1,500 cubic feet per minute, or about 14 percent. of the normal estimated quantity. At that time the original doors and stoppings in the connections between intake and return had been blown out and replaced by temporary sheets, so that the quantity would be considerably less in any case than that passing prior to the explosion. Dr. Willett also suggested that as firedamp was found bleeding off from roof breaks in the inbye length of intake—a not uncommon phenomenon after an explosion—it might have been bleeding off before the explosion. On his theory, firedamp from this source would, of course, help to account for the presence of flame on this part of the intake and across the working face, but not on South 3 Gate.

53. I am quite unable to accept these views. Firedamp had not been reported in the district since July 9th. Persons were at work in it until two hours before the explosion and did not detect any and it seems at least unlikely from their known actions afterwards that there was any substantial quantity of gas in the air current at the meeting station when the three officials first got there at about 10.30 p.m. Prior to the explosion the percentage of firedamp normally present in South 2 Conveyor Gate, as found by analyses, was of the order of 0.6 per cent., and the quantity of air passing where the firedamp was said to have exuded was 5,950 cubic feet per minute. If only 6 per cent. of firedamp was present at the meeting station at the time of the explosion—and probably there was more—then the air in South 2 Conveyor Gate must have contained about 18 per cent. of firedamp, on the basis that about 15,500 cubic feet per minute normally passed the meeting station. Moreover, after the explosion the maximum quantity of firedamp found was 3 per cent. The opinion that the fall in the intake which so reduced the flow of air to the face occurred before the explosion was based on what seemed to me to be very slender and unconvincing evidence. It was just the place where I should have expected a fall to occur as a result of the explosion.

54. I have given the fullest consideration to all the evidence and to the views of the expert witnesses, and I have thought long myself about the basic question of the source of the firedamp which caused this explosion. It seems to me certain that the inner door between the entrances to Old North 1 District was fixed in position prior to the explosion and that its destruction was caused by the explosion. There was no other acceptable explanation to account for the damage. No one disputed that if the door were hung and closed or partly closed, firedamp would be forced out of Old North 1 District and circulate around the South 2 District, and I have come to the conclusion that this actually occurred. I am unable to account for the indications of the passage of flame along the intake airway in any other way. In my opinion the hanging of the door occurred during the night shift but it is not possible to say with certainty which of the five persons in the district at the time did it.

55. At the Coroner's Inquest, which was concluded subsequent to my Inquiry, the jury found that the firedamp came from Old North 1 District and that it was ignited by a spark from a flame safety lamp opened contrary to regulations. They considered that tests for firedamp should have been made deeper into the old district than at the entrances where the fences were erected or, better still, that it should have been permanently sealed off from the remainder of the workings. I shall refer to this question later.

VI.—OBSERVATIONS ON THE COURSE OF THE EXPLOSION

56. As we have seen, evidence of the passage of flame in various places was given by Mr. Rees, Dr. Tideswell, Dr. Willett and others, Dr. Tideswell's conclusions being aided by his examination of samples of dust and other materials under the microscope. It is clear that flame had been present on the South 2 face and in most of the intake and return airways to that face, including at least South 3 on the intake and the 1 in 7 Drift on the Evison Bord outbye the meeting station in the return haulage road. In the intake, flame did not travel far, if at all, outbye South 3. In the return, outbye the 1 in 7 drift in the Evison Bord, coked dust and charred ends of string provided evidence that flame had actually travelled to within 200 yards of the junction with the South Ending. The evidence of Dr. Sutherland that the bodies of the victims found in the 1 in 7 Drift were burnt and that death had been immediate or almost immediate strongly confirms the presence of flame in the drift. But the fact that he did not find burns on the four bodies recovered at the outbye end of

the drift may be thought to throw some doubt on the presence of flame there. It is possible, however, that these men may have been partly buried by a fall caused by the "pioneering wave" of the explosion before flame reached them, or that the flame had missed the exposed parts of their bodies in some way as, for example, by flame passing above them as they lay flat on the floor.

57. Taking the source of the ignition as the opened lamp at the meeting station on the Evison Bord—and no one was able to suggest any other point of ignition—I visualise the course of the explosion as follows :—

- (a) First, flame travelled in both directions along the Evison Bord, the outbye flame travelling not only with its own natural speed, but being forced in addition by the blast of air projected backwards from the flame advancing towards the dead-end provided by the several coal faces inbye.
- (b) Flame was projected immediately after the ignition a short way down both gates of Old South 1.
- (c) The doors and stopping in the two slits between the intake and return, and opposite the two gates of Old South 1, were blown when the pressure on them became great enough. This was not necessarily while the flame was still in that vicinity but may have been a second or so later during the passage of the flame farther inbye. The door which was hung in the intake to divert the air into Old North 1 was destroyed when the blast first entered the intake airway through the outbye slit.
- (d) The flame penetrated into South 3 by blowing the brattice sheets and doors in the Evison Bord between South 2 Conveyor Gate and South 3 face, and into South 2 face along the South 2 Conveyor Gate. In its passage along the South 2 Gate, the flame branched into the Gledhill Crossgate and travelled along South 2 intake tail gate to South 2 face.
- (e) Part or all of South 2 face was traversed by flame which came from either the Conveyor Gate or the intake tail gate or from both.
- (f) Flame from South 3 travelled outbye along the intake and died out somewhere near the junctions of the entrances to Old North 2. It did not travel further outbye along the intake, either because insufficient inflammable gas was by that time coming from old North 1, or because the atmosphere coming from it contained such a high percentage of firedamp that, even after dilution with whatever air was mingling with it on the main road, there was more than 14 per cent. of firedamp present and the air was therefore non-inflammable.

58. The evidence that can be derived from the "lines of force" of an explosion has been valuable on many occasions as an indication of the direction of travel of the explosion. Despite the fact that careful records of all such signs had been made in this case by various witnesses to the inquiry, nevertheless their significance was ambiguous. Dr. Willett argued that the "lines of force" radiated from the vicinity of the transfer point on South 2 Conveyor Gate, and not from the meeting station on the Evison Bord. This led him to suspect the former as the starting point of the explosion, but he was unable to point to any possible source of ignition there, or indeed, anywhere else than the opened lamp at the meeting station. On the other hand Mr. E. S. Rees considered the evidence of direction of force was consistent with the explosion starting at the meeting station.

VII.—THE INFLUENCE OF COAL DUST

59. No one disputed that this explosion began as a firedamp explosion, but there were some differences of opinion as to the part subsequently played by coal dust. There was very little evidence of coking visible to the naked eye.

Indeed, the only coking that could be readily discerned in this way was mainly in South 3 conveyor gate, on the left side of South 2 face, and a patch or two in a few other places.

60. Mr. E. S. Rees thought coal dust played a very minor part in the propagation of the explosion and considered sufficient firedamp was driven out of old North 1 District to account for its extent. Dr. Tideswell found "a very extensive deposition of fine coke dust over the whole of the area which I have concluded was traversed by flame, but it was not obvious to the eye ; it only became evident when the dust samples taken were examined under the microscope." He went on to say that in his view the explosion was mainly one of firedamp, although he was prepared to believe that it was extended by coal dust along the outbye length of the Evison Bord, and was assisted locally here and there by coal dust, especially in South 2 Conveyor Gate. If it was entirely a firedamp explosion—and he saw nothing inconsistent with such an assumption—some 15,000 cubic feet of pure firedamp would be required to propagate it through the 3,000 yards in which he found indications of flame. Such a quantity, he thought, could be present in Old North 1 District. He was not able to "distinguish between a firedamp explosion which raised coal dust in the flame and coked it, and one in which there was not enough firedamp to have burned without coal dust being there." He thought it likely that coal dust would be picked up from the conveyor belt and perhaps from the roadways and, in that sense, coal dust would take part in the propagation ; but that did not mean that the explosion would not have been propagated by firedamp alone had there been no coal dust present. He said that generally it was difficult to have a firedamp explosion in a colliery in which coal dust is not involved. In this explosion he considered coal dust did not play a decisive part.

61. Dr. Willett, while agreeing that the explosion started as a firedamp explosion, thought coal dust played a definite and more than a minor part in its propagation. Having heard the evidence about the breaking of the belt in South 2 Conveyor Gate on the day-shift, he thought there would be sufficient coal dust on the belt and from roadway spillage to be raised into the air as a cloud and "that was the way in which the explosion was extended as far as it was." He said he could not tell to what extent coal dust played a part but, in answer to a question put by me, he said in his opinion coal dust played a greater part than firedamp in the spread of the explosion. This view was no doubt influenced by the fact that on his theory of the source of the firedamp there would be insufficient inflammable gas to account for the extent of the explosion unless assisted by coal dust.

62. Although I am of the opinion that the evidence did not warrant the wide divergence of view between Dr. Willett and other witnesses as to the part played by coal dust in this explosion, nevertheless, that there should be some variance of opinion as to the extent to which coal dust played a part is not strange. The fact that patches of coke dust were found in certain places proves no more than that the dust agglomerated into these patches had been exposed to heat, which might have been the heat of the burning of firedamp or of the burning of coal dust, or heat in unknown proportions from both these sources. So far as I am aware, the significance of post explosion effects of this kind has received very little experimental study and, in the present lack of knowledge, a finding as to the part, if any, played by coal dust in extending a firedamp explosion is usually not a fact established by direct evidence as much as an inference from opinions previously formed as to the probable extent of the firedamp explosion. This is not a happy position and experimental work might well be attempted with the object of clarifying it.

63. Apart from the experimental difficulties, severe limitations might well arise in applying experimental results obtained under a comparatively narrow range of conditions to the widely varying, and always to some degree unknown, conditions of an actual pit explosion. But, nevertheless, an attempt ought to be made and two lines of attack occur to me :—

- (a) An estimation of the amount of coking, or “ashing”, of coal dust which occurs on explosion in air alone and in a firedamp-air mixture ; and the influence of excess or deficiency of oxygen, of the presence of incombustible dust and of sudden variations, e.g., hold-ups, in the speed of propagation of the explosion ;
- (b) An examination of post explosion samples (such as could be collected after an actual pit explosion), with a view, if possible, to discriminating in relation to the proportion of unburned coal dust between the residues of coal dust distilled without burning and coal dust wholly or partly burned.

64. As I have just indicated, it is not possible to say with certainty that coal dust contributed to this explosion, or if it did, to say to what extent. The dust samples collected on the roads after the explosion contained, on the average, about 70 percent. of incombustible matter. Now it has long been known, from large scale experimental explosions made in this and other countries, that in the presence of small amounts of firedamp a greater percentage of incombustible dust—in direct proportion to the percentage of firedamp in the air—is needed to protect the coal dust. In other words, this means that while the dust conditions and the firedamp conditions may, separately, be perfectly safe, in combination they may be otherwise. In a roadway where there is a liability to firedamp, as will normally be the case in a return airway in a safety lamp mine, an increase in the percentage of stone dust on the floor, roof and sides, above that required to deal with coal dust alone is, therefore, essential. If we assume there was 3 per cent. of firedamp in the atmosphere in any of the roadways traversed by the explosion, then it would have required at least 80 per cent. of incombustible matter in the dust on that roadway to protect the coal dust present and prevent propagation of flame.

65. In view of these possibilities, it becomes necessary to review the measures taken by the management to discharge their obligations under the General Regulations (Precautions against Coal Dust) 1939. Mr. Aston, Under-Manager, said that three men—one on each shift—were regularly employed cleaning up the dust on the conveyor roads. The system was to clean up for a length of six or eight trays, including the part under the belt, on each shift and then stone dust this length. The loading points and transfer points were cleaned up every day. A sample was taken from each zone (176 yards in length) every month. The number of samples taken during the three months ending 31st August, 1947, was 156, of which 5 were slightly adverse. The places where these adverse samples were taken were cleaned up, redusted and resampled as soon as possible. One man was continuously employed on cleaning up and stone dusting the haulage roads in the Beeston and Wheatley Lime Seams.

66. In general, it is difficult in practice to maintain the percentage of incombustible matter required by the Regulations on conveyor roads which are intake airways. It becomes more difficult still to maintain safe conditions where the conveyor road is a return airway in which inflammable gas is likely to be present. In this explosion there is nothing to suggest a major coal dust explosion developing from a small firedamp explosion. Nevertheless, there is perhaps a little doubt and possibly a slight risk in assuming that coal dust played only a very minor part and, consequently, this explosion—like the recent explosions at

Louisa Colliery, Durham, and Whitehaven "William" Pit, Cumberland—directs attention once again to the need for more research into the deposition of coal dust in conveyor roadways and the best means of counteracting it. Whilst the conditions in many parts of the Wheatley Lime Seam at this Colliery could be considered dry and dusty, they were not strikingly so. Several parts of the district were damp. Nevertheless, as I said in my recent Report on the explosion at the Whitehaven "William" Pit, when dealing with the danger from coal dust in conveyor roadways, "I should like to press the point very strongly that if compliance with the dust regulations at all times in dry and dusty mines is to be reasonably assured, and the conditions in such mines are to be improved in respect of health and comfort, then all practicable steps must be taken in the first instance to prevent or reduce dust formation *at its source* and to suppress by water infusion, sprays and wet-cutting, wet-drilling or other appropriate means, any dust that is inevitably made." And in view of the fact that the required percentage of incombustible dust required to protect the coal dust must be increased in amount in direct proportion to the percentage of inflammable gas present in the air, it follows that one of the practical steps that should be taken is to avoid the use of return airways for the conveyance of coal. Unless suitable means can be devised for combating the coal dust danger from conveyors, it may be necessary to consider the prohibition of coal conveying in any return airway in a safety lamp mine.

VIII.—ADDITIONAL COMMENTS

(a) *On the Presence and Removal of the Accumulation of Firedamp in Old North 1 District*

67. It was known to the management that the abandoned workings in Old North 1 District contained a substantial body of firedamp. It must also have been known that when these old workings filled with firedamp, the "make" would almost certainly find its way into the intake air current entering the working districts of the Wheatley Lime Seam. It does appear, however, that the "make" was small because, prior to the explosion, there was no history of any appreciable fouling of the intake air entering the working district, while the results of air analyses showed that the normal firedamp content of the air in the return airway from the working faces was about 0·6 per cent. Nevertheless, the position with respect to this Old North 1 District was such that it is disturbing to find that no positive steps were taken to deal with the firedamp made in the old workings: it was bounded by faults and its entrances joined the intake airway as the air entered a working district in which electricity was extensively used and shotfiring extensively practised. Either the old district should have been stowed, importing material for the purpose, if necessary, or the district should have been sealed off by efficient stoppings, or steps should have been taken to maintain the circulation of sufficient air round the old workings to prevent an accumulation of firedamp and ensure that the firedamp swept out was diluted and rendered harmless. As I said in my recent Report on the Explosion at the Whitehaven "William" Colliery, Cumberland, "a reservoir of inflammable gas anywhere in a mine is always a potential source of danger; but it becomes a lively hazard if it is near, or may react upon, a working place, or near any possible source of ignition." When it is known that a substantial accumulation of inflammable gas exists anywhere in a working mine, the matter should receive the careful consideration of the higher management, who should decide what is to be done about it and the agreed policy should be made clearly known to the under officials in charge in the area and efficient steps taken to see that the policy is carried out.

68. Where a large accumulation is known to exist and steps have to be taken to sweep it out, the operation should only be done on a well-considered plan and under the close supervision of a superior official. Clearing away a large accumulation of gas is not a simple and easy operation, and unless it is done very carefully it may easily lead to serious trouble. Clearly, such an operation should not be done during a normal working shift and the means for doing it should not be so handy that it can be applied by any junior official without the knowledge of the higher management. It should certainly not be so easy as it was in this particular instance, where for a year or more all that was necessary was to place a door on its hanging post—an operation that could be performed by anyone in a few minutes and without attracting much notice.

(b) On the Use of Lead Rivet Locks on Flame Safety Lamps

69. As I have already stated, the source of ignition in this explosion was the operation of the relighting device, which was probably considered by the operator not to be functioning properly, of a flame safety lamp after the lamp had been taken apart by the cutting of the lead rivet by which the lamp was locked. It may be recalled that an exactly similar action was believed to be the source of ignition in the Explosion at the Harrington No. 10 Colliery, Cumberland, on the 9th December, 1946 (Report Cmd. 7222). Because of the ease with which a flame safety lamp locked by a lead rivet can be opened, the question of the prohibition of this type of lock is worthy of careful consideration. There is no doubt whatever that a lamp secured by a lead rivet is much easier to open than one secured by a magnetic lock, although it is not unknown for even a magnetically locked lamp to be opened illegally underground. On the other hand, if the lead rivet is properly squeezed by a rivetting device which leaves a distinctive mark, and if the lamps are properly examined, as they should be, when they are returned to the lamproom the chance of the offender being detected is much greater with the lead rivet than the magnetic lock. But I am afraid these safeguards, without which the lead rivet is hardly a lock at all, are by no means always taken—and even if they were it must not be forgotten that there are circumstances in a mine when the temptation to open a flame safety lamp is very strong, even at some risk of subsequent detection. When a flame lamp has been extinguished or the relighting device is not functioning satisfactorily, to have the lamp relit or to secure another lamp may mean in certain circumstances travelling a long distance outbye, or a long wait for another lamp to be brought from the surface that may seem to the person concerned a waste of valuable time, more especially in an emergency when he may be in difficulty or danger. Human nature being what it is, the easier it is to do a thing one is tempted to do, the more likely is one to succumb to the temptation. There is, therefore, some justification for the prohibition of the lead rivet lock. In present circumstances, with all the difficulties of supply, I do not, however, feel justified in recommending its prohibition forthwith, but I do suggest that the policy in this matter should be to eliminate the lead rivet lock and replace it by an efficient magnetic lock, as circumstances permit, and that the changeover should be effected in all cases where existing flame safety lamps, fitted with a lead rivet type of lock, are due for substantial reconditioning or complete replacement.

(c) On the Need for an Improved Form of Relighting Device for Flame Safety Lamps

70. It is highly probable that in the present explosion and in the recent one at Harrington No. 10 Colliery, Cumberland, the primary reason for the opening of the flame safety lamp, believed to be the source of ignition in both explosions, was a defect in the lamp relighting device. The Pyrophor relighting device

incorporated in a flame safety lamp works on the same principle as the common type of cigarette lighter. It is by no means wholly reliable. There is undoubtedly a need for a more efficient and positive type of relighter. I feel there is scope here for the scientist and inventor and I commend this suggestion for their attention.

IX.—SUMMARY OF CONCLUSIONS

71. Summarising the results of the Inquiry, I find that :—

(1) The source of ignition in this explosion was a spark produced by the operation of the relighting device of flame safety lamp No. 9 after the deliberate removal of the spirit vessel which had been made possible by the cutting of the lead rivet lock ; the lamp was opened in order to adjust the internal relighter, which was believed not to be functioning properly ; the opening of the lamp was a grave misdemeanour and a contravention of Section 34 (1) (iii) of the Coal Mines Act, 1911 ; there were two men, a deputy and a shotfirer—both subsequently killed by the explosion—at the meeting station in the return airway and main haulage road from the Wheatley Lime Seam District when the relighting device was operated in the opened lamp, but there is no evidence to show who actually opened the lamp and who then operated the relighter.

(2) The spark from the relighter in the opened lamp ignited an inflammable firedamp-air mixture in the general body of the air current passing the meeting station at the time, causing a firedamp explosion.

(3) The flame of the explosion traversed a distance of approximately 3,000 yards, including nearly all of the inbye working roads and faces and more than 1,000 yards along the main return haulage road outbye the meeting station.

(4) The explosion developed moderate violence in the South 2 Conveyor Gate and in the 1 in 7 Drift in the Evison Bord haulage road, but elsewhere the explosion was mild in character.

(5) The explosion was mainly one of firedamp and it is not possible to say with certainty that coal dust contributed to it, or if it did, to what extent.

(6) The main source of the firedamp was the abandoned workings in the Old North 1 District ; this firedamp was forced out of the Old North 1 District by the fixing and closing, or nearly closing, of a door in the intake airway between the two entrances to the old district ; this door had been fixed on the night shift about half-an-hour or thereby before the explosion occurred ; and it is not possible to say which of the five persons in the district at the time fixed the door.

X.—RECOMMENDATIONS

72. As a result of the Inquiry, I make the following recommendations :—

(a) *Part Played by Coal Dust in Estimating a Firedamp Explosion*

(1) In view of the present lack of knowledge as to the part, if any, played by coal dust in extending a firedamp explosion, experiments should be made to clarify the position, and I suggest two lines of attack :—

(i) An estimation of the amount of coking, or "ashing", of coal dust which occurs on explosion in air alone and in a firedamp-air mixture ; and the influence of excess or deficiency of oxygen, of the presence of incombustible dust and of sudden variations, e.g., hold-ups, in the speed of propagation of the explosion.

(ii) An examination of post-explosion dust samples (such as could be collected after an actual pit explosion) with a view, if possible, to discriminating in relation to the proportion of unburned coal dust between the residues of coal dust distilled without burning and coal dust wholly or partly burned.

(b) Coal Conveying in Return Airways in a Safety Lamp Mine

(2) Until efficient and suitable means can be found for combating the coal dust danger from conveyors, the management at all safety lamp mines should take steps to avoid the use of return airways for the conveyance of coal.

(c) Prevention and Removal of Accumulations of Gas

(3) In mines where firedamp is likely to accumulate in abandoned workings steps should be taken either (i) to stow the abandoned roadways, importing material where necessary, or (ii) to maintain sufficient ventilation to prevent an accumulation of gas and to dilute and render harmless the gas that is removed, or (iii) to seal off the old workings by efficient stoppings, the method adopted to be determined by the circumstances in each case.

(4) When it is known that a substantial accumulation of inflammable or noxious gases exists anywhere in a working mine, the method of dealing with it should be considered by the management, who should decide what is to be done. The agreed policy should be made known to all officials in the area concerned and steps should be taken to see that it is properly carried out.

(5) Where a large accumulation of gas is known to exist and steps have to be taken to clear it, the operation should only be done on a well-considered plan under the close supervision of a superior official of the mine and at a time when few persons are in the pit.

(d) Lead Rivet Locks for Flame Safety Lamps

(6) Because of the ease with which a flame safety lamp, secured by a lead rivet lock, can be opened it should be the policy to eliminate all such locks and replace them by efficient magnetic locks, as the circumstances of the supply position permit. In the meantime the changeover should be made in all cases where existing flame safety lamps, fitted with the lead rivet lock, are due for substantial reconditioning or for complete replacement.

(e) Improved Form of Relighting Device

(7) In view of the unreliability of the existing type of Pyrophor Relighter for flame safety lamps, an effort should be made to devise a more positive and efficient relighter device.

XI.—ACKNOWLEDGMENTS

73. Finally, I desire to record my sincere thanks for the help and co-operation of the representatives of all parties to the Inquiry and to Mr. F. A. Castleton, Clerk of Court. I am specially indebted to the North Eastern Division of the National Coal Board for the excellent and numerous plans provided and to Dr. H. F. Coward and members of the staff of the Safety in Mines Research and Testing Branch, and Major H. J. Humphrys, H.M. Divisional Inspector of Mines, for much valuable assistance.

I have the honour to be, Sir,

Your obedient Servant,

A. M. BRYAN.

APPENDIX I

LIST OF WITNESSES

1.	Benjamin Taylor Nowell	..	Surveyor
2.	Thomas Green..	..	H.M. Assistant Inspector of Mines
3.	Bernard Aston	..	Under Manager
4.	Peter Lindsay Sutherland	..	Pathologist, West Riding County Council
5.	Alfred Bernard Allport	..	Deputy
6.	Claude Barber..	..	Deputy
7.	Ralph Lawrence Parker	..	H.M. Assistant Electrical Inspector of Mines
8.	Arthur William Fisher	..	Ripper
9.	Ernest Smithson	..	Ripper
10.	William Crawshaw	..	Byeworker
11.	Arthur Littlewood	..	Deputy
12.	John Rodgers ..	..	Ripper
13.	Harry Wraithmell	..	Lampman
14.	John Francis Taylor ..	..	Assistant Lampman
15.	Herbert Collomosse ..	..	Onsetter.
16.	Harold Edmundson ..	..	Byeworker
17.	George William Kitson	..	Deputy
18.	Clifford Cyril Riley ..	..	Superintendent, Brierley Rescue Station
19.	Isaac Keaton ..	..	Assistant Superintendent, Wakefield Rescue Station
20.	Claude Bernard Meister Platt		Superintending Testing Officer, Ministry of Fuel and Power
21.	Edward Sims Rees ..	..	H.M. District Inspector of Mines
22.	Walter Clarke ..	..	Ripper
23.	Eric Edward Cleaver ..	..	Agent and Manager
24.	Frederick Vincent Tideswell..		Senior Principal Scientific Officer, Minis- try of Fuel and Power
25.	Harry Leslie Willett ..	..	Principal, Research and Safety Depart- ment of North Eastern Division, National Coal Board

APPENDIX II

LIST OF CASUALTIES

	NAME			AGE	OCCUPATION
<i>Killed</i>					
1.	Fred William Pearson	..	..	40	Deputy
2.	Bernard Hewitt	..	..	42	Shot-firer
3.	Clifford Howarth	..	..	20	Beltman
4.	Arthur Wilson	..	..	44	Beltman
5.	George Walshaw	..	..	32	Ripper
6.	Milton Frudd	..	..	51	Machineman
7.	Ernest Johnson	..	..	68	Byeworker
8.	George Grayson	..	..	49	Byeworker
9.	Percy Robertshaw	..	..	49	Ripper
10.	Percy Ellis	..	..	54	Ripper
11.	John Middleton	38	Drawer
12.	Stanley Middleton	37	Drawer
<i>Injured</i>					
1.	Jesse Clarke	34	Shot-firer

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